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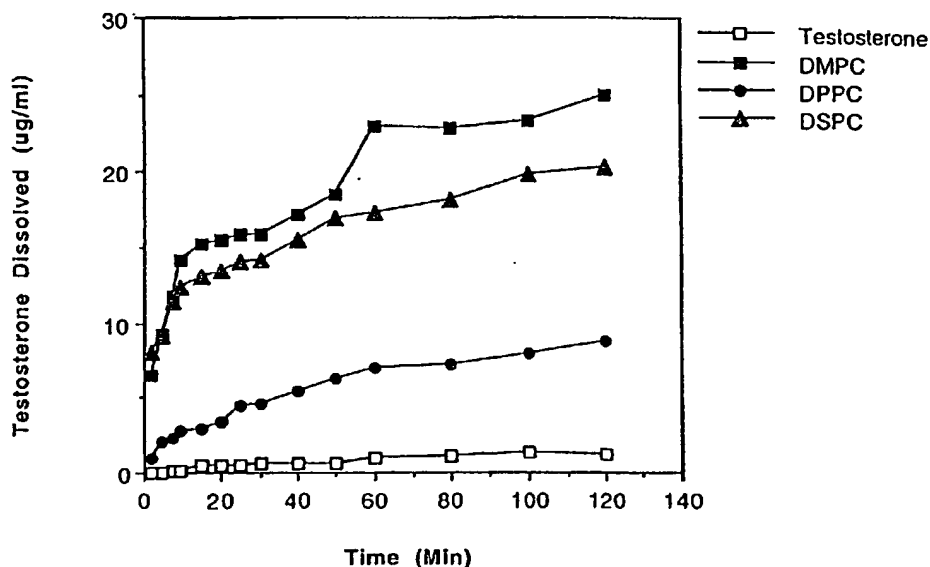
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(54) Title: PROLIPOSOMAL DRUG DELIVERY SYSTEM

## DISSOLUTION OF TESTOSTERONE FROM PROLIPOSOMAL FORMULATIONS AND PURE TESTOSTERONE



(57) Abstract: This invention relates to proliposomal drug-delivery systems for medicaments. In particular, it relates to enteric-coated proliposomal formulations for poorly water soluble drugs and methods for making the same. The drug delivery system comprises a pharmaceutical agent, a phospholipid and a coating material. The present invention provides enhanced stability and bioavailability for pharmaceutical formulations.

WO 02/085304 A2

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WO 02/085304

PCT/US02/13062

**PROLIPOSOMAL DRUG DELIVERY SYSTEM**Background of the InventionField of the Invention

- 5           This invention relates to proliposomal drug-delivery systems for medicaments. In particular, it relates to enteric-coated proliposomal formulations for poorly water soluble drugs.

Description of the Related Art

- 10           Pharmaceutical formulations may be administered through various routes of administration. For example, drugs may be administered orally, intravenously, subcutaneously and by aerosol. The encapsulation of pharmaceuticals in liposomes is useful in reducing toxicity and improving the therapeutic effectiveness of certain drugs. For example, compounds such as insulin, factor VIII, tryptophan, phenylalanine, heparin, vitamin K etc., have been investigated for their effectiveness orally, after encapsulation into liposomes. Although they represent an improvement over the prior art, oral liposome formulations have been criticized because of their instability, leakage and potential destruction in gastric fluids.

- 15           The use of proliposomes represents an alternative to conventional liposomal formulations. Proliposomes are dry, free-flowing granular products, which, upon the addition of water, disperse to form a multilamellar liposomal suspension. The stability problems associated with conventional liposomes, including aggregation, susceptibility to hydrolysis and oxidation, may be avoided by using proliposomes. The use of proliposomes is well known in the pharmaceutical field.

- 20           Among the various routes of drug administration, the oral route is advantageous because of its versatility, safety and patient comfort. Although the oral ingestion of drugs represents a safe and versatile method of pharmaceutical delivery, the therapeutic efficacy of many drugs is reduced because many pharmaceuticals are labile or inactivated under the acidic conditions of the stomach. Enteric coating materials have been applied to address this deficiency. Enteric coating materials are those that ensure that acid-labile  
25           drugs remain active in the stomach upon oral ingestion such that the active ingredient is released and absorbed in the intestine. Enteric coatings materials are well known in the pharmaceutical art and include alginates, alkali-soluble acrylic resins, hydroxypropyl methylcellulose phthalate, cellulose acetate phthalate, and the like.

- 30           Although the use of proliposomes and the use of enteric and non-enteric coatings are independently known in the art, the combination of a coating with a proliposomal formulation has not been disclosed. Surprisingly, when a coating of the current invention is combined with a proliposomal formulation of the current invention, drug delivery is enhanced. In many embodiments of the present invent, this novel and unexpected enhancement, which results from the unique combination of a coating and a proliposomal formulation, relates to increased drug absorption, stability and bioavailability.

WO 02/085304

PCT/US02/13062

In many embodiments of the current invention, the combination of a coating and a proliposomal formulation overcomes the disadvantages of drug delivery systems known in the prior art. For example, the utility of previous systems for orally administering labile pharmacological substances has been limited by the need to use toxic amounts of delivery agents, the instability of the systems, the inability to protect the active ingredient, the inability to effectively deliver drugs that are poorly water soluble or labile, the inadequate shelf life of the systems, the failure of the drug delivery systems to promote absorption of the active agent and the difficulties inherent to manufacturing the systems.

#### Summary of the Invention

The current invention relates to a drug delivery system comprising at least one pharmaceutically active agent, at least one phospholipid and a coating material. A particular advantage of the current invention is that it provides a simple and inexpensive system to facilitate the administration of medicaments. In many embodiments, this drug delivery system enhances the stability and bioavailability of pharmaceutically active agents.

According to one aspect of this invention, the pharmaceutical formulation is administered through various routes including, but not limited to, oral, buccal, sublingual, nasal, topical, transdermal, ophthalmic, vaginal, rectal, intravesical, pulmonary, intra-arterial, intravenous, intradermal, intramuscular, subcutaneous, intraperitoneal, intrathecal and intraocular.

In one aspect of the invention, the coating material is an enteric coating. In another aspect, the coating is a non-enteric coating.

In one embodiment, the coating includes a plasticizer. One advantage of the plasticizer is that it increases the flexibility of the coating. Moreover, the plasticizer reduces the possibility of coating rupture and pore formation.

In one embodiment, the enteric coating includes, but is not limited to, cellulose acetate phthalate, alginates, alkali-soluble acrylic resins, hydroxypropyl methylcellulose phthalate, methacrylate-methacrylic acid copolymers, polyvinyl acetate phthalate, styrol maleic acid copolymers, shellac, and cellulose acetate.

In another embodiment, the non-enteric coating includes, but is not limited to methylcellulose, ethylcellulose, hydroxyethylcellulose, methylhydroxyethylcellulose, hydroxypropylcellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose, povidone, and polyethylene.

In yet another embodiment, the coating is a film plasticizer selected from the group consisting of phthalate esters, citrate esters and triacetin.

In one aspect of the invention, the pharmaceutically active agent is a poorly water soluble drug.

In another aspect of the invention, the phospholipid is distearoyl phosphatidylcholine, dipalmitoyl phosphatidylcholine or dimyristoyl phosphatidylcholine and the enteric coating material is cellulose acetate phthalate.

WO 02/085304

PCT/US02/13062

In another aspect of the invention, a pharmaceutical formulation is delivered in a tablet, capsule, suspension and/or liquid form. In alternative embodiments, carriers, diluents and/or lubricants are also included in the pharmaceutical formulation.

Another aspect of the invention relates to a method for making the drug delivery system comprising  
5 combining at least one pharmaceutically active agent with at least one phospholipid, and thereafter coating the combination with a coating material. In alternate embodiments, pharmaceutically inactive agents, such as carriers, diluents and lubricants, are also included in the drug delivery system. Placebo may also be delivered according to certain embodiments of the invention.

A further aspect of the invention relates to a method for delivering a pharmaceutical formulation to a  
10 mammal by administering the formulation to the mammal. In specific embodiments, the current invention relates to preventing, diagnosing or treating an illness in a mammal with the drug delivery system of the present invention.

#### Brief Description of the Drawings

FIG. 1 shows a comparison among dissolution rates of testosterone using various proliposomal  
15 formulations and pure testosterone.

FIG. 2 shows a comparison between dissolution rates of famotidine using a proliposomal formulation (DSPC) and pure famotidine.

#### Detailed Description of the Preferred Embodiment

Several embodiments of present invention relate to enteric coated proliposomal formulation  
20 comprising a pharmaceutically active agent, a phospholipid and an enteric coating material. In preferred embodiments, the enteric coated proliposomal (EnProLip™) formulation enhances the dissolution and bioavailability of drugs. The effect is more pronounced for drugs with extremely low water solubility, such as halofantrine and testosterone. A less pronounced rate of dissolution is observed with drugs with higher water solubilities, such as famotidine. In one embodiment, the current invention consists of a drug delivery system  
25 which provides a more rapid onset of drug action, a longer duration of action and an increased  $C_{max}$  as compared to administration of the drug alone.

In a preferred embodiment, the formulation comprises

- (a) a poorly water soluble drug;
- (b) distearoyl phosphatidylcholine (DSPC), dipalmitoyl phosphatidylcholine (DPPC) or dimyristoyl  
30 phosphatidylcholine (DMPC); and
- (c) cellulose acetate phthalate.

In one embodiment, the pharmaceutically active agent is a poorly water soluble drug. Poorly water soluble drugs are pharmaceutically active agents which require greater than approximately thirty (30) parts of solvent per one (1) part of solute to dissolve. Examples of poorly water drugs include, but are not limited to,  
35 griseofulvin, famotidine, meclizine, cyclosporine, carbamazepine, methotrexate, itraconazole, dipyridamole,

WO 02/085304

PCT/US02/13062

mercaptapurine, halofantrine, amiodarone, lomustine, testosterone, misoprostil, etoposide, rifamycin, azathioprine, glyburide, tolbutamide, aminoglutethimide, taxol, clofibrate, nifedipine, methyldopa, ramipril, dicumarol, and the like. One skilled in the art will appreciate that this invention is not limited to poorly water soluble drugs but includes a wide range of pharmaceutically active and inactive agents. Drugs that are slightly soluble, sparingly soluble or hydrophilic may also be delivered using various embodiments of the present invention.

In a preferred embodiment, DSPC, DPPC or DMPC is used as the phospholipid. One skilled in the art will understand that other phospholipids, including, but not limited to, egg PC, soy PC, DMPG, DMPA, DPPG, DPPA, DSPG, DSPA, phosphatidylserine, sphingomyelin, and the like may be used.

10 In a preferred embodiment, cellulose acetate phthalate is used as the enteric coating. However, one skilled in the art will appreciate that alginates, alkali-soluble acrylic resins, hydroxypropyl methylcellulose phthalate, methacrylate-methacrylic acid copolymers, polyvinyl acetate phthalate, styrol maleic acid copolymers, shellac, cellulose acetate and the like may also be used. One skilled in the art will also appreciate that the enteric coating material used in various embodiments of the invention may include a combination of the aforementioned coatings.

15 In one aspect of the invention, the coating material is a non-enteric coating. Non-enteric coatings include, but are not limited to methylcellulose, ethylcellulose, hydroxyethylcellulose, methylhydroxyethylcellulose, hydroxypropylcellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose, povidone, and polyethylene. One skilled in the art will also appreciate that the non-enteric coating material used in various embodiments of the invention may include a combination of the aforementioned enteric and non-enteric coatings.

In one embodiment, the coating includes a plasticizer. One advantage of the plasticizer is that it increases the flexibility of the coating. Moreover, the plasticizer reduces the possibility of coating rupture and pore formation. Plasticizers include, but are not limited to, phthalate esters, citrate esters and triacetin.

25 In one embodiment of the invention, the enteric coated proliposome delivery system will be used for anti-emetic purposes by preventing the release of noxious ingredients in the stomach, thereby reducing nausea and other adverse side effects.

In another embodiment of the invention, the enteric coated proliposomal formulation is used to deliver drugs which are susceptible to degradation in the intestinal tract.

30 In another embodiment, the current invention will be used to administer drugs through various routes. Several embodiments will also be used to enhance delivery of drugs or other substances in the food industry, where enzyme immobilization is essential for various aspects of food processing.

In a further embodiment, the current invention will be used to treat a mammal comprising administering to the mammal a pharmaceutically active agent, a phospholipid and a coating material.

WO 02/085304

PCT/US02/13062

One skilled in the art will understand that the current invention is not limited to the delivery of drugs or pharmaceutical agents. Any number of naturally occurring or synthetic substances, including diagnostic agents and therapeutic materials, may be delivered according to the current invention. These substances include, but are not limited to, anorexics, analgesics, antiarthritics, adrenergic blocking agents, steroids, vaccines, peptides, proteins, hormones, antibodies, antibiotics, antiviral agents, vitamins, nucleotides, nutritional agents, enzymes, genes, genetic material, cytotoxins, bacteria, microbes, viral agents, and the like. Placebo may also be administered using various embodiments of the current invention. Diluents, carriers, lubricants and the like, including, but not limited to, microcrystalline cellulose, starch, lactose, talc, mannitol, polyethylene glycol, polyvinylpyrrolidone, hydroxypropylmethyl cellulose, ethyl cellulose, fatty acids, fatty acid salts, glyceryl behenate, dextrose, dicalcium phosphate may also be administered using several embodiments of the present invention.

Further, one skilled in the art will understand that the amount of the active pharmaceutical or substance used in the current invention will depend on the dose required to be administered and the treatment desired. One skilled in the art will appreciate that "treatment" refers to any desired purpose for administering the pharmaceutically active ingredient, including prevention, control, cure, maintenance or improvement of health, and the like. By varying the concentration of the ingredients, size, number and/or amount of tablets, capsules, suspension or liquid, a wide range of doses may be orally administered. Time-released drugs may also be administered according to various embodiments of the present invention.

One skilled in the art will also appreciate that the current invention is not limited to the delivery of a single pharmaceutical agent. Indeed, more than one pharmaceutical agent may be delivered simultaneously using the current drug delivery system. For example, in one "dose", the recipient may receive a combination of two or more drugs, at least one drug and a carrier, etc.

In one embodiment of the invention, the drug delivery system is synthesized in the following manner:

At least one pharmaceutically active agent and at least one phospholipid are dissolved in solvent at appropriate ratios and concentrations. Upon dissolution, the solvent is evaporated to yield a dry powder-like material. The dried material is passed through a sieve-like apparatus. This dried material is then coated with an enteric coating, which is preferably in solution and can be sprayed onto the dried material. The coated particles are then used to synthesize tablet, capsule or liquid preparations suitable for delivery to a mammal.

Several embodiments of the current invention are particularly advantageous because they allow for the enteric coating to be applied *after* the pharmaceutically active agent and phospholipid are mixed. This permits preparation of different forms of the formulation, including, tablets, capsules, suspensions, or liquids. Moreover, various embodiment of the present invention allow for the facile preparation of tablets of various sizes. The size of the tablets is preferably controlled by adjusting the pore size of the mesh or sieve.

I previously described a method for preparing drugs in a tablet or capsule form with an enteric coating. However, a particular advantage of various embodiments of the current invention is the ability to

WO 02/085304

PCT/US02/13062

generate suspension or liquid forms of the formulation. Suspension or liquid forms are sometimes preferable because they do not affect gastrointestinal motility to the same extent as do capsules or tablets. For most drugs, it is important that the pharmaceutically active compound is not eliminated in the gastrointestinal tract before it has had a chance to exert a localized effect or to pass into the bloodstream. When a  
5 formulation is in a suspension or liquid form, it is typically retained in the intestine for longer periods of time and, as such, absorption is increased as compared to capsules or tablets. Various aspects of this invention also provide for flexibility in the surface area of the formulation. Whereas tablets are generally restricted to a fixed surface area, several embodiments of the present invention permit the use of capsules, suspensions and liquids, which may provide a larger surface area and hence contribute to increased absorption and  
10 bioavailability.

I previously described a method for delivering drugs in which the drug was exposed to an aqueous phase. According to several embodiments of the current invention, the lipid and the drug are exposed to chloroform, or similar solvent. There is no exposure to an aqueous phase. For water sensitive drugs and drugs that are labile in water, such as antibodies, the absence of an initial aqueous phase preserves the  
15 integrity of these drugs. Further, because there is no exposure to an aqueous phase, liposomes are not formed. Hence, several embodiments of the current invention are directed to non-liposomal pharmaceutical formulations. As used herein, "non-liposomal" is defined as a formulation which is not exposed to an aqueous phase, and thus does not form liposomes, prior to the application of the enteric coating.

Not wishing to be bound by the following description, it is believed that various embodiments of the  
20 current invention work in the following manner: After formation of the proliposome formulation, the formulation is orally delivered to a mammal. When the proliposome formulation encounters an aqueous phase at a pH at or above approximately 7.0, liposomes are formed and the drug molecules are transported across the gastrointestinal membrane.

#### *Specific Routes of Administration*

25 According to one aspect of this invention, the pharmaceutical formulation is administered through various routes including, but not limited to, oral, buccal, sublingual, nasal, topical, transdermal, ophthalmic, vaginal, rectal, intravesical, pulmonary, intra-arterial, intravenous, intradermal, intramuscular, subcutaneous, intraperitoneal, intrathecal and intraocular.

With respect to the transdermal route, several embodiments of this invention are particularly  
30 advantageous because iontophoretic transdermal delivery of drugs is hindered if the drug molecules are not charged at pH suitable for this kind of delivery. However, an enteric-coated proliposomal formulation in accordance with various embodiments of the current invention may be successfully used for transdermal delivery. The enteric coating protects the drug from acidic pH. The charge on the liposomes facilitates drug delivery by iontophoretic transdermal delivery. Embodiments of this invention are especially useful for water-  
35 insoluble drugs or poorly soluble drugs. Typically, in order deliver drugs iontophoretically, the drug must first



WO 02/085304

PCT/US02/13062

be dissolved. Therefore, water-insoluble drugs or poorly soluble drugs are difficult to administer by this method. In accordance with several embodiments of the present invention, however, the water-insoluble drugs or poorly soluble drugs can be incorporated in liposomes for delivery by this route. To facilitate preparation of drugs for transdermal delivery, the formulation may be suspended in an aqueous phase to facilitate absorption from the skin. The pH of the solution is preferably neutral to facilitate dissolution of the coating

In one embodiment of the current invention, a method for nasal administration is provided. If local action of a drug is desired instead of a systemic effect, the proliposomal formulations of several embodiments described herein are ideal because they are non-irritating to the mucosal membranes. The formulation is believed to non-irritating because the mucosa is primarily in contact with the lipid bilayers, rather than directly with the irritating drug. The release of drug from liposome is in a sustained fashion and readily miscible with secretions covering these membranes.

In another embodiment of the current invention, a method for pulmonary administration is provided. Proliposomes have been shown to be a very useful and efficient system for pulmonary drug delivery. The proliposomal formulations can be administered using dry powder inhalers. Administration of proliposomal formulations by pulmonary route can modify pulmonary absorption, resulting in localized drug action in the respiratory tract, a prolonged drug presence in the circulation and decreased systemic side effects. Hence, from a toxicological viewpoint, proliposomes would seem a particularly appropriate system for drug delivery to the lungs.

If administration of the pharmaceutical formulations described herein are to be delivered to a target in which the environment is acidic, the enteric coating may not dissolve, thus hampering drug release. Therefore, in several embodiments of this invention, a non-enteric coating is provided. These non-enteric coatings include polymers that dissolve at acidic, basic and neutral pH. Based upon the desired target tissue for drug delivery, one skilled in the art will understand which type of coating should be used in accordance with the present invention.

One skilled in the art will have sufficient information to make and use the non-liposomal formulations of the present invention by adapting the Examples provided below for cellulose acetate phthalate.

The following Examples illustrate various embodiments of the present invention and are not intended in any way to limit the invention.

**EXAMPLE 1:**

Halofantrine and distearoyl phosphatidylcholine (1:3 ratio) were dissolved in chloroform and the solvent was evaporated using nitrogen gas. The dry powder was passed through a # 60 mesh screen. Cellulose acetate phthalate (50 mg) was dissolved in acetone (6 ml) and sprayed on the halofantrine and distearoyl phosphatidylcholine mixture.

WO 02/085304

PCT/US02/13062

Dissolution was carried out using 40 mg of the formulation using a Type II USP dissolution apparatus. The dissolution medium (250 ml) was phosphate buffered saline (pH 7.4). The temperature of the dissolution media was maintained at  $37 \pm 0.5$  °C and the rotation of the paddle was set at 50 rpm. Samples (5 ml) were withdrawn at 5, 10, 15, 30, 45, 60, 90, 120, 180 and 240 minutes. Equal volumes of phosphate buffered saline were added to maintain a constant volume of dissolution media.

The samples were analyzed by high performance liquid chromatography (HPLC). In the mobile phase, 46.5:53.5 (0.025 M potassium phosphate/sulfuric acid/triethylamine solution):acetonitrile was combined, mixed and filtered using a Kontes filter apparatus. Sodium dodecyl sulfate (1.1 g/L of mobile phase) was added to the filtered solution.

The parameters of the assay procedure was as follows. The flow rate was set at 1.2 ml/minute. The temperature was ambient. The run time was 30 minutes. The ultraviolet light detector was set at a wavelength of 254 nm. The retention times for (+) halofantrine and (-) halofantrine were 25 minutes and 28 minutes respectively.

The pharmacokinetic parameters of the enteric coated proliposomal formulation of halofantrine were evaluated as follows. The proliposomal product was prepared as a suspension in 0.78% methylcellulose. A non-liposomal suspension formulation (control) was prepared by dispersing halofantrine powder in 1% methylcellulose. Sprague-Dawley rats were cannulated at the right jugular vein under halothane anesthesia. After an overnight rest, the rats were given 7 mg/kg of a halofantrine suspension as either the proliposomal (7 rats) or control (6 rats) formulation by oral gavage. Serial blood samples were obtained from the cannula until 48 h post-dose. A stereospecific HPLC assay was used to measure plasma concentration of halofantrine enantiomers. Noncompartmental pharmacokinetic methods were used to determine  $AUC_{0-24}$ ,  $C_{max}$  and  $t_{max}$ . Student's unpaired t-test was used to assess significance of differences. Results (mean  $\pm$  SD) are provided in Table 1.

Table 1. Pharmacokinetic Results of the Halofantrine Study

	AUC, $\mu$ g h/mL		C <sub>max</sub> , ng/mL		T <sub>max</sub> , h	
	Control	Liposome	Control	Liposome	Control	Liposome
(+)-HF	5.2 $\pm$ 0.81 <sup>b</sup>	7.7 $\pm$ 1.8 <sup>ab</sup>	391 $\pm$ 59.2 <sup>b</sup>	722 $\pm$ 170 <sup>ab</sup>	7.0 $\pm$ 2.8	4.1 $\pm$ 2.3
(-)-HF	1.9 $\pm$ 0.53	2.6 $\pm$ 0.66 <sup>a</sup>	196 $\pm$ 42.3	360 $\pm$ 80.5 <sup>a</sup>	4.6 $\pm$ 2.1	4.0 $\pm$ 1.3

a = p<0.05 compared to control; b = p<0.05 compared to antipode

The proliposomal formulation displayed higher bioavailability of both enantiomers than did the control formulation. The AUC and  $C_{max}$  of halofantrine enantiomers increased by over 40% and 80%, respectively. Although the mean  $t_{max}$  was lower for both enantiomers in the proliposomal formulation, the differences from control were not statistically significant.

WO 02/085304

PCT/US02/13062

**EXAMPLE 2:**

Testosterone and phospholipid (DMPC, DPPC or DSPC; 1:1 ratio) were dissolved in chloroform. Chloroform was evaporated using nitrogen gas. The dry powder was passed using a # 60 mesh sieve. Cellulose acetate phthalate (40 mg) was dissolved in acetone (5 ml) and the resulting solution was sprayed  
5 on the solid dispersion containing the testosterone and phospholipid. Nitrogen gas was used to dry the powder.

Dissolution was carried out using 45 mg of the formulation using a Type II USP dissolution apparatus. The dissolution medium (300 ml) was phosphate buffered saline (pH 7.4). The temperature of the dissolution media was maintained at  $37 \pm 0.5$  °C and rotation of the paddle was set at 50 rpm. The samples  
10 (5 ml) were withdrawn at 2, 5, 8, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100, and 120 minutes. Equal volumes of phosphate buffered saline were added to maintain a constant volume of dissolution media. Dissolution samples were analyzed by measuring the absorbance at 254 nm.

The rate and extent of dissolution of testosterone was significantly greater with all proliposomal formulations as compared to pure testosterone as shown in Fig. 2. The extent of dissolution was highest with  
15 the proliposomal formulation containing DMPC, followed by DSPC and DPPC. This may be explained by the phase transition temperature ( $T_c$ ) of these lipids. DPPC has a  $T_c$  of 41°C, which is very close to the temperature of the dissolution study (37 °C). DMPC and DSPC have  $T_c$ 's of 23 °C and 56 °C respectively. DMPC exists in a fluid state and DSPC in a gel state at 37 °C. Because the  $T_c$  of DPPC was similar to the temperature of the dissolution study, the formulation may have been unstable, thus hampering the dissolution  
20 of testosterone. Nonetheless, the data indicates that the rate and extent of dissolution of testosterone was increased by using the enteric coated proliposomal formulation.

**EXAMPLE 3:**

Famotidine and distearoyl phosphatidylcholine (DSPC; 1:3 ratio) were dissolved in chloroform. Chloroform was evaporated using nitrogen gas. The dry powder was passed using a # 60 mesh sieve.  
25 Cellulose acetate phthalate (50 mg) was dissolved in acetone (5 ml) and the resulting solution was sprayed on the solid dispersion containing testosterone and phospholipid. Nitrogen gas was used to dry the powder.

Dissolution was carried out using 87 mg of the formulation using a Type II USP dissolution apparatus. The dissolution medium (300 ml) was phosphate buffered saline (pH 7.4). The temperature of the dissolution media was maintained at  $37 \pm 0.5$  °C and the paddle rotation was set at 50 rpm. The samples (5  
30 ml) were withdrawn at 2, 5, 8, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100, and 120 minutes. Equal volumes of phosphate buffered saline were added to maintain a constant volume of dissolution media. Dissolution samples were analyzed by measuring the absorbance at 285 nm.

The rate of dissolution of famotidine formulation was significantly greater than pure famotidine. However, there was no significant increase in the extent of dissolution of famotidine in PBS. Because the  
35 proliposomal formulation results in a faster rate of dissolution, the onset of drug action will be more rapid.

WO 02/085304

PCT/US02/13062

While a number of preferred embodiments of the invention and variations thereof have been described in detail, other modifications and methods of use will be readily apparent to those of skill in the art. Accordingly, it should be understood that various applications, modifications and substitutions may be made of equivalents without departing from the spirit of the invention or the scope of the claims.

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WO 02/085304

PCT/US02/13062

WHAT IS CLAIMED IS:

1. A non-liposomal pharmaceutical formulation comprising:  
 at least one pharmaceutically active agent;  
 at least one phospholipid; and  
 5 a coating material surrounding said pharmaceutically active agent and said phospholipid.
2. The formulation of Claim 1, wherein said coating is adapted for administration through various routes selected from the group consisting of oral, buccal, sublingual, nasal, topical, transdermal, ophthalmic, vaginal, rectal, intravesical, pulmonary, intra-arterial, intravenous, intradermal, intramuscular, subcutaneous, intraperitoneal, intrathecal and intraocular.
- 10 3. The formulation of Claim 1, wherein said pharmaceutically active agent is a poorly water soluble drug.
4. The formulation of Claim 1, wherein said pharmaceutically active agent is selected from the group consisting of griseofulvin, famotidine, meclizine, cyclosporine, carbamazepine, methotrexate, itraconazole, dipyridamole, mercaptopurine, halofantrine, amiodarone, lomustine, testosterone, misoprostil,  
 15 etoposide, rifamycin, azathioprine, glyburide, tolbutamide, aminoglutethimide, taxol, clofibrate, nifedipine, methyldopa, ramipril and dicumarol.
5. The formulation of Claim 1, wherein said phospholipid is a phosphatidyl phospholipid.
6. The formulation of Claim 1, wherein said phospholipid is selected from the group consisting of distearoyl phosphatidylcholine, dipalmitoyl phosphatidylcholine, dimyristoyl phosphatidylcholine, egg PC, soy PC, DMPG, DMPA, DPPG, DPPA, DSPG, DSPA, phosphatidylserine and sphigomyelin.  
 20
7. The formulation of Claim 1, wherein said coating is an enteric coating.
8. The formulation of Claim 7, wherein said enteric coating is selected from the group consisting of cellulose acetate phthalate, alginates, alkali-soluble acrylic resins, hydroxypropyl methylcellulose phthalate, methacrylate-methacrylic acid copolymers, polyvinyl acetate phthalate, styrol maleic acid  
 25 copolymers, shellac, and cellulose acetate.
9. The formulation of Claim 1, wherein said coating is a non-enteric coating.
10. The formulation of Claim 9, wherein said non-enteric coating is selected from the group consisting of methylcellulose, ethylcellulose, hydroxyethylcellulose, methylhydroxyethylcellulose, hydroxypropylcellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose, povidone, and  
 30 polyethylene.
11. The formulation of Claim 1, wherein said coating comprises a plasticizer.
12. The formulation of Claim 11, wherein said plasticizer is selected from the group consisting of phthalate esters, citrate esters and triacetin.
13. The formulation of Claim 1, wherein said pharmaceutically active agent is selected from the  
 35 group consisting of anorexics, analgesics, antiarthritics, adrenergic blocking agents, steroids, vaccines,

WO 02/085304

PCT/US02/13062

peptides, proteins, hormones, antibodies, antibiotics, antiviral agents, vitamins, nucleotides, nutritional agents, enzymes, genes, genetic material, cytotoxins, bacteria, microbes and viral agents.

14. The formulation of Claim 1, wherein said formulation is in a form selected from the group consisting of capsules, suspensions and liquids.
- 5 15. The formulation of Claim 1, wherein said formulation is in tablet form.
16. The formulation of Claim 1, further comprising at least one additional ingredient which is pharmaceutically inactive.
17. The formulation of Claim 16, wherein said at least one additional ingredient is selected from the group consisting of carriers, diluents and lubricants.
- 10 18. The formulation of Claim 16, wherein said at least one additional ingredient is selected from the group consisting of microcrystalline cellulose, starch, lactose, talc, mannitol, polyethylene glycol, polyvinylpyrrolidone, hydroxypropylmethyl cellulose, ethyl cellulose, fatty acids, fatty acid salts, glyceryl behenate, dextrose and dicalcium phosphate.
19. A method for making the pharmaceutical formulation of Claim 1, comprising:
- 15 combining a pharmaceutically active agent with a phospholipid to produce a combination; and
- coating said combination with a coating material to produce a coated product.
20. The method of Claim 19, further comprising forming said coated product into a capsule, liquid or suspension.
- 20 21. The method of Claim 19, wherein said coating material is adapted for administration through various routes selected from the group consisting of oral, buccal, sublingual, nasal, topical, transdermal, ophthalmic, vaginal, rectal, intravesical, pulmonary, intra-arterial, intravenous, intradermal, intramuscular, subcutaneous, intraperitoneal, intrathecal and intraocular.
22. The method of Claim 19, wherein said pharmaceutically active agent is a poorly water
- 25 soluble drug.
23. The method of Claim 19, wherein said pharmaceutically active agent is selected from the group consisting of griseofulvin, famotidine, meclizine, cyclosporine, carbamazepine, methotrexate, itraconazole, dipyridamole, mercaptopurine, halofantrine, amiodarone, lomustine, testosterone, misoprostil, etoposide, rifamycin, azathioprine, glyburide, tolbutamide, aminoglutethimide, taxol, clofibrate, nifedipine,
- 30 methylidopa, ramipril and dicumarol.
24. The method of Claim 19, wherein said phospholipid is a phosphatidyl phospholipid.
25. The method of Claim 19, wherein said phospholipid is selected from the group consisting of distearoyl phosphatidylcholine, dipalmitoyl phosphatidylcholine, dimyristoyl phosphatidylcholine, egg PC, soy PC, DMPG, DMPA, DPPG, DPPA, DSPG, DSPA, phosphatidylserine and sphigomyelin.
- 35 26. The method of Claim 19, wherein said coating is an enteric coating.

WO 02/085304

PCT/US02/13062

27. The formulation of Claim 27, wherein said enteric coating is selected from the group consisting of cellulose acetate phthalate, alginates, alkali-soluble acrylic resins, hydroxypropyl methylcellulose phthalate, methacrylate-methacrylic acid copolymers, polyvinyl acetate phthalate, styrol maleic acid copolymers, shellac, and cellulose acetate.
- 5 28. The formulation of Claim 19, wherein said coating is a non-enteric coating.
29. The formulation of Claim 28, wherein said non-enteric coating is selected from the group consisting of methylcellulose, ethylcellulose, hydroxyethylcellulose, methylhydroxyethylcellulose, hydroxypropylcellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose, povidone, and polyethylene.
- 10 30. The formulation of Claim 19, wherein said coating comprises a plasticizer.
31. The formulation of Claim 30, wherein said plasticizer is selected from the group consisting of phthalate esters, citrate esters and triacetin.
32. The method of Claim 19, wherein said coating comprises spraying said combination with said coating material.
- 15 33. The method of Claim 19, further comprising combining at least one additional ingredient which is pharmaceutically inactive with said pharmaceutically active agent.
34. The method of Claim 33, wherein said at least one additional ingredient is selected from the group consisting of carriers, diluents and lubricants.
35. The method of Claim 33, wherein said at least one additional ingredient is selected from the group consisting of microcrystalline cellulose, starch, lactose, talc, mannitol, polyethylene glycol, polyvinylpyrrolidone, hydroxypropylmethyl cellulose, ethyl cellulose, fatty acids, fatty acid salts, glyceryl behenate, dextrose and dicalcium phosphate.
- 20 36. The method of Claim 19, wherein said pharmaceutically active agent is selected from the group consisting of anorexics, analgesics, antiarthritics, adrenergic blocking agents, steroids, vaccines, peptides, proteins, hormones, antibodies, antibiotics, antiviral agents, vitamins, nucleotides, nutritional agents, enzymes, genes, genetic material, cytotoxins, bacteria, microbes and viral agents.
- 25 37. A method of making the pharmaceutical formulation of Claim 1, comprising:  
combining at least one pharmaceutically active agent with at least one phospholipid in a non-aqueous solvent;
- 30 evaporating said non-aqueous solvent; and  
applying a coating material to said pharmaceutically active agent and said phospholipid.
38. The method of Claim 37, wherein said coating material is adapted for administration through various routes selected from the group consisting of oral, buccal, sublingual, nasal, topical, transdermal, ophthalmic, vaginal, rectal, intravesical, pulmonary, intra-arterial, intravenous, intradermal, intramuscular,
- 35 subcutaneous, intraperitoneal, intrathecal and intraocular.

WO 02/085304

PCT/US02/13062

39. The method of Claim 37, wherein said pharmaceutically active agent is a poorly water soluble drug.
40. The method of Claim 37, wherein said pharmaceutically active agent is selected from the group consisting of griseofulvin, famotidine, meclizine, cyclosporine, carbamazepine, methotrexate, 5 itraconazole, dipyridamole, mercaptopurine, halofantrine, amiodarone, lomustine, testosterone, misoprostil, etoposide, rifamycin, azathioprine, glyburide, tolbutamide, aminoglutethimide, taxol, clofibrate, nifedipine, methyl dopa, ramipril and dicumarol.
41. The method of Claim 37, wherein said phospholipid is a phosphatidyl phospholipid.
42. The method of Claim 37, wherein said phospholipid is selected from the group consisting of 10 distearoyl phosphatidylcholine, dipalmitoyl phosphatidylcholine, dimyristoyl phosphatidylcholine, egg PC, soy PC, DMPG, DMPA, DPPG, DPPA, DSPG, DSPA, phosphatidylserine and sphigomyelin.
43. The method of Claim 37, wherein said coating is an enteric coating.
44. The formulation of Claim 43, wherein said enteric coating is selected from the group consisting of cellulose acetate phthalate, alginates, alkali-soluble acrylic resins, hydroxypropyl methylcellulose 15 phthalate, methacrylate-methacrylic acid copolymers, polyvinyl acetate phthalate, styrol maleic acid copolymers, shellac, and cellulose acetate.
45. The formulation of Claim 37, wherein said coating is a non-enteric coating.
46. The formulation of Claim 45 wherein said non-enteric coating is selected from the group consisting of methylcellulose, ethylcellulose, hydroxyethylcellulose, methylhydroxyethylcellulose, 20 hydroxypropylcellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose, povidone, and polyethylene.
47. The formulation of Claim 37, wherein said coating comprises a plasticizer.
48. The formulation of Claim 47, wherein said plasticizer is selected from the group consisting of phthalate esters, citrate esters and triacetin.
- 25 49. The method of Claim 37, wherein said applying said coating material comprises spraying said pharmaceutically active agent and said phospholipid with said enteric coating material.
50. The method of Claim 37, further comprising combining at least one additional ingredient which is pharmaceutically inactive with said pharmaceutically active agent.
51. The method of Claim 50, wherein said at least one additional ingredient is selected from the 30 group consisting of carriers, diluents and lubricants.
52. The method of Claim 50, wherein said at least one additional ingredient is selected from the group consisting of microcrystalline cellulose, starch, lactose, talc, mannitol, polyethylene glycol, polyvinylpyrrolidone, hydroxypropylmethyl cellulose, ethyl cellulose, fatty acids, fatty acid salts, glyceryl behenate, dextrose and dicalcium phosphate.



WO 02/085304

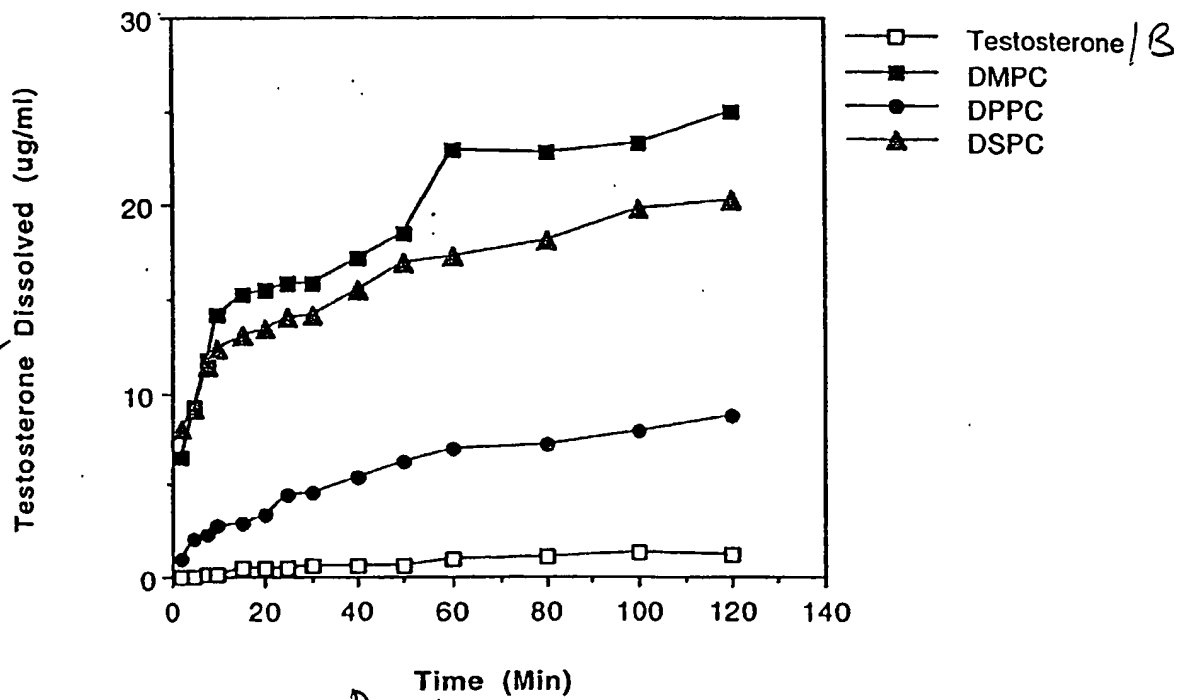
PCT/US02/13062

53. The method of Claim 37, wherein said pharmaceutically active agent is selected from the group consisting of anorexics, analgesics, antiarthritics, adrenergic blocking agents, steroids, vaccines, peptides, proteins, hormones, antibodies, antibiotics, antiviral agents, vitamins, nucleotides, nutritional agents, enzymes, genes, genetic material, cytotoxins, bacteria, microbes and viral agents.
- 5 54. The method of Claim 37, wherein said formulation is in a form selected from the group consisting of capsules, suspensions and liquids.
55. The method of Claim 37, wherein said formulation is in tablet form.
56. A method for delivering the pharmaceutical formulation of Claim 1 to a mammal comprising administering said pharmaceutical formulation to said mammal.
- 10 57. The method of Claim 56, wherein said administering further comprises administering said pharmaceutical formulation through various routes selected from the group consisting of oral, buccal, sublingual, nasal, topical, transdermal, ophthalmic, vaginal, rectal, intravesical, pulmonary, intra-arterial, intravenous, intradermal, intramuscular, subcutaneous, intraperitoneal, intrathecal and intraocular.
58. A method for diagnosing, preventing or treating an illness in a mammal comprising
- 15 administering the pharmaceutical formulation of Claim 1, wherein said pharmaceutical agent is provided in a biologically active dose.
59. The method of Claim 58, wherein said administering further comprises administering said pharmaceutical formulation through various routes selected from the group consisting of oral, buccal, sublingual, nasal, topical, transdermal, ophthalmic, vaginal, rectal, intravesical, pulmonary, intra-arterial,
- 20 intravenous, intradermal, intramuscular, subcutaneous, intraperitoneal, intrathecal and intraocular.
60. A method for diagnosing, preventing or treating an illness in a mammal comprising orally administering the pharmaceutical formulation of Claim 7, wherein said pharmaceutical agent is provided in a biologically active dose.

WO 02/085304

PCT/US02/13062

A | DISSOLUTION OF TESTOSTERONE FROM PROLIPOSOMAL FORMULATIONS AND PURE TESTOSTERONE



D

FIGURE ONE (1)

WO 02/085304

PCT/US02/13062

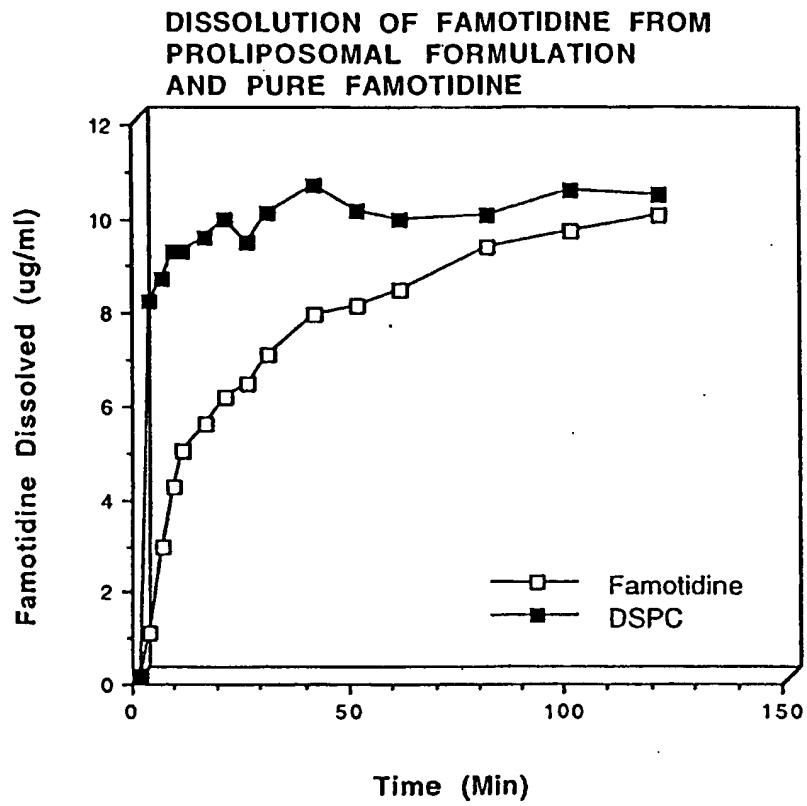


FIGURE TWO (2)

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